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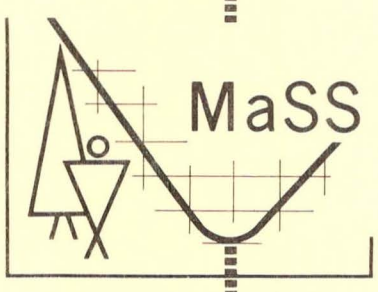
Methodology of Program Budgeting on a National Forest: The Eldorado Experience - PART A

Malcolm W. Kirby



Management Sciences Staff

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METHODOLOGY OF PROGRAM BUDGETING ON A NATIONAL FOREST: THE ELDORADO EXPERIENCE

by

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PART A

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PREFACE

This, the second of a series of three reports on Program Budgeting on the Eldorado National Forest, is in two parts denoted A and B, each of which is bound separately. The first report of the series entitled, "An Overview of a Study in Program Budgeting on a National Forest" contains the background, the design criteria, the conduct, and a critique of our experience. This report contains only the technical material and is therefore, not self-contained. In particular, the design criteria for the system is in the first report. The third report is entitled, "PPBS - Automatic Data Processing Description and Specifications for One-year Forest Model Automation" and was written by Phillip Haug, Division of Administrative Management, Chief's Office, formerly of the Management Sciences Staff.

The author gratefully acknowledges the contributions of others to this report. The section on "Measuring Changes in Outputs" is due to Miles Hill of the Management Sciences Staff who did the bulk of the work in collecting and editing the output measures used by the Eldorado. Most of Section VII is taken from actual computer runs and also appears in the report by Phillip Haug cited above. Part B (Sections VIII and IX) is entirely due to Supervisor I. Bosworth, Deputy Supervisor S. Hall, W. Shirley, and other members of the Eldorado National Forest.

PART A

CONTENTS

		Page
	PREFACE	
	LIST OF EXHIBITS	
I.	INTRODUCTION	1
II.	KEY FEATURES OF THE PROTOTYPE BUDGETING SYSTEM	3
	A. Summary of the Procedure	3
	B. Measuring Changes in Outputs	9
	C. A Summary of Joint Outputs for the F.Y. 1970 Project Bank	17
	D. Constraints to Insure Feasibility	22
	E. The Man-hours by Skill by Season Required for the F.Y. 1970 Program	25
III.	PROGRAM BUDGETING AND OVER-HEAD DISTRIBUTIONS	31
IV.	MODELS FOR OPTIMAL PROJECT SELECTION AND MANPOWER ALLOCATION	33
	A. The Concept of Land Management Activities	33
	B. The Linear Programming Formulation	33
	C. Output Values and Effectiveness Measures	38
	D. Marginal Values (shadow prices)	41
	E. Efficient Points and Non-Uniqueness of Output Prices	44
	F. The Simplex Algorithm as a Method for Expansion Along an Optimal Path	45
	G. Notes on the Manpower Network Flow Computations	45
V.	USING THE ELDORADO ADP SYSTEM FOR OTHER PURPOSES	47
	A. Solving Other Problems	47
	B. Linking Outputs to Inventories	51
VI.	NOTES ON SERVICE-WIDE MODELS	53
	A. Model No. 1	53
	B. A Functional Regional Model	55
	C. Using the Same Model for Proposals and Allocating	55
	D. The Decomposition Principle	57
VII.	SAMPLE PRINT-OUTS OF THE FINAL REPORTS (D4.0 - D13)	59
	REFERENCES	61

LIST OF EXHIBITS

		Page
1.	ADVANCE APPROPRIATION TARGETS	6
2.	TIME TABLE FOR FISCAL YEAR 1971	8
3.	NATIONAL FOREST WORK CATEGORIES, SHOWING OUTPUTS COMMONLY ASSOCIATED WITH PROJECTS IN EACH CLASS	13
4.	NUMBER OF OUTPUT COEFFICIENTS NEEDED FOR ELDORADO PPB - 1969	14
5.	AN EXAMPLE OF COEFFICIENT DEVELOPMENT FOR TIMBER REGENERATION (Growth)	15
6.	AN EXAMPLE OF COEFFICIENT DEVELOPMENT FOR TIMBER STAND IMPROVEMENT	16
7.	JOINT MULTIPLE OUTPUTS (ACTUAL IN PHYSICAL UNITS)	18
8.	JOINT MULTIPLE OUTPUTS (RELATIVE)	19
9.	JOINT MULTIPLE OUTPUTS (ACTUAL IN %)	20
10.	JOINT MULTIPLE OUTPUTS (RELATIVE IN %)	21
11.	MAN HOURS BY SEASON BY SKILL FOR THE F.Y. 1970 PROGRAM	29
12.	COMMON PROBLEMS FOR THE ANNUAL BUDGET MODEL	40
13.	SAMPLE PRINTOUTS OF THE FINAL REPORTS	61

I. INTRODUCTION

The management activities carried out on National Forest lands typically yield multiple outputs. A timber management activity, for example, yields merchantable timber, provides water run-off, and changes the wildlife habitat potential of the forest. Similarly, range management activities make substantial contributions to the production of water and to recreation. The multiple-output character of forest management was recognized by the Congress in the Multiple-Use-Sustained-Yield Act of 1960. This Act directs the Forest Service to carry out multiple-use management which means joint production of some combination of timber, water, forage, recreation, etc. Ecological relations complicate the evaluation of changes in composition of the output "bundle" because it is not generally possible to increase only one output. For example, increasing timber cut usually tends to increase water run-off. Thus, only certain combinations of outputs are possible. The complexity of this problem suggests the use of powerful analytical tools.

By definition costs cannot be uniquely allocated to each of the joint outputs. Some writers recommend allocating all costs to a single output. This step is reasonable only if this output is of paramount importance--either by virtue of its intrinsic value or because the other outputs are produced almost independently--but neither case characterizes multiple use management of land.

The results of an analysis based on an arbitrary allocation should be regarded with skepticism because one set of numbers is as theoretically correct as another, and the allocation of costs can be shifted by clever people to obtain a favorable comparison. Therefore it is unrealistic to compare multiple-output programs within an agency or between agencies on the basis of cost allocation.

Another approach assumes that all project costs and benefits be specified in dollar values. Each output is assigned a dollar value and all dollar values are summed. This approach

appeals to some economic analysts--it allows them to calculate present values and internal rates of return on investments. But, in the absence of a market for an output, the dollar value of an output is a proxy value which may not make sense to management.

Also, we feel that comparing timber planting with range re-seeding, for example, purely in economic terms is an over simplification because even if the economic returns are identical, the outputs are not; and, it is for outputs not profit that investments are made in public lands.

Our approach recognizes the need to display outputs in explicit terms. It provides a convenient method for generating a wide spectrum of alternative output bundles. Also, where there is a choice of activities which yield the same bundle, our approach recognizes that some choices are more efficient than others and selects the best. Our approach permits a manager to use one of several optional definitions of efficiency, including the use of proxy output values as discussed above.

II. KEY FEATURES OF THE PROTOTYPE PROGRAM BUDGETING SYSTEM

A. Summary of the Procedures

Following are procedures necessary to implement the one year budget model. The steps are in sequence but some of them can be taken concurrently.

1. *The Regional Forester decides upon areas of emphasis for each forest.* These areas can be based upon the Chief's Program of Work and Regional demand projections for the various outputs.
2. *Determine short and long-range goals for the Forest.* These are the one and five year goals (in quantifiable output terms where possible), at two levels - maximum and minimum (see section VIII for examples).
3. *All functional plans and programs must be updated and coordinated* including all multiple-use considerations. (The plan includes; (a) timber, range, recreation, watershed, wildlife resource management plans, (b) administrative site plans, transportation system plans, fire prevention and pre-suppression plans, (c) construction and maintenance plans, including fire and general purpose, recreation, communication systems). This is essentially the same as we do now, but, the budget model makes coordination of these plans mandatory.
4. *Determine outputs from the present level of operation.* These are in physical units (timber growth, animal months of forage, acre feet of water, etc.) - not intermediates (acres treated, miles built, etc). This information is developed by Forest Staff, and approved by Supervisor and Rangers. Much of this data will eventually be included as part of INFORM. Changes in the present levels of outputs will be the basis for reporting accomplishments.
5. *Forest Staff establish guidelines for priorities and furnish planning advice,* including specifications and standards where needed.

6. *Rangers and Forest Staff develop project work proposals (PWP).* The form used is an extension of the present Form No. 1300-4. The PWP, used as the primary source for input data, is modified to include; (a) manpower hours required, designated by occupation specialty (e.g., geneticist, scaler, engineering contracts supervisor); (b) changes in physical outputs in absolute and-or relative terms (coefficients); (c) direct costs only; (d) a priority designation. Forty-two percent of the projects used in the Fiscal Year 1969 programs were included in PWI categories. If the PWI were revised to include the additional information needed in items a through d above it would become, in effect, a set of PWPs and more of the PWI could be included in our analysis. A sample of the PWP is included in the forest instruction manual. (Section IX).
7. *Staff review and recommend approval of Project Work Proposals* - Review technical adequacy, completeness, correct output information, and priorities where applicable. Staff specialists must provide output data for all projects - not just those whose funding corresponds to their functional specialty. Where needed, Regional Office Staff should be consulted to be sure that output data used is the best available.
8. *Supervisor approve Project Work Proposals to be included in model.* (This is a line function, and we assumed should not be delegated to staff).
9. *Forest Staff develop fixed costs* - A list of these is in the forest's instruction manual which appears in Section IX of this report.
10. *Develop a forest manpower inventory.* (The network is a standardized part of the program). Districts and Staff provide manpower inventory data, by categories and hours available in each category, and business management staff then computes average wage costs per

hour or submit the data to the regional ADP shop for machine computation (if they are used in costing the project for selection purposes).

11. *Regional Budget Officer advises Forest of appropriation targets.* Eventually this might be eliminated and the 5-year model should be used to request appropriation amounts. *Exhibit 1 shows the Eldorado appropriation targets for F. Y. 1969. Note that these targets were given in August 1967!*
12. *Keypunch, audit, and develop alternate Forest Programs of Work* by computer.
13. *Supervisor select alternate proposals* to be presented to Regional Forester for approval, recommend one.
14. *Regional Forester approve a proposed Program.*
15. *Implement the program:*
    Ranger - Execute the work.
    Forest Staff - Inspect for compliance with standards, report deviations and exceptions, recommend change where needed.
    Supervisor - Approve plan revisions.
    Regional Office Staff - Control work through inspections; compare what has been done against what was planned to be done; concentrate on results.
16. *Report progress and accomplishment* - all levels.
17. *Update Forest level of outputs* to reflect the increase (or decrease) based on what has been done because of the current program - this should show all changes in output - plus or minus.

EXHIBIT 1

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

ADVANCE APPROPRIATION TARGETS

REPLY TO: 6510

August 31, 1967

SUBJECT: Appropriations & Funds (F.Y. 1969 Estimates)

TO: Donald R. Ball, Chief,
Division of Operation

Attached are our preliminary estimates of Fiscal Year 1969 levels of financing for the Eldorado. These data are furnished for use in the PPBS Pilot Project.

We have included an estimated distribution of Forest general expenses (Form 6500-10). Since the responsibilities for general expenses are assigned to the various appropriations following final determination of other financial levels, we assume you will need to know the amount of general expenses we have included in each appropriation total.

Attachment (next page)

DONALD R. BALL

F. Y. 1969 FINANCIAL PLANNING ESTIMATES
ELDORADO PPBS PROJECT

8/31/67

Appropriation	6500-10 Gen. Exp.	All Other	Less Quarters Ded.	Total
P&M	178,600	1,930,900	- 11,000	2,098,500
I&DC	1,400	16,000		17,400
WRDRA	14,400	389,100		403,500
FR&T	88,200	1,877,800		1,966,600
K-V	20,100 3/	1/		
State Fire	5,000	56,900		61,900
Other Coop	4,240 2/	1/		
W. C. F.	15,700	150,000		165,700
Brush Disposal	2,300 3/	1/		
Prog. Direction - Job Corps	20,000	11,500		31,500
Center Operation - Job Corps		690,000		690,000
	349,940			5,434,500

1/ Forest to estimate.
2/ Based on F.Y. 1968 level of Coop, the Gen. Expense for F.Y. 1969 will be approximately $4,240.
3/ Based on Forest estimates of F.Y. 1968 expenditures.

EXHIBIT 2

TIMETABLE FOR FISCAL YEAR 1971

Due Date	
November 5 & 6, 1969	Training Session and review of Eldorado Forest objectives and goals.
November 30, 1969	Annual Plans of Work (1300-3), Fire Protection Budget (5100-8), and Centralized Overhead Budget (S.O.only), are due in the S. O.
December 15, 1969	50% of all Project Work Plans for all sub-units are due on this date.
January 1, 1970	Last acceptable date for submission of remaining Project Work Plans.
January 1, 1970	Audit and record controls completed.
January 20, 1970	Complete approval on all 1300-4's and 1300-3's.
February 1, 1970	Key punch all input documents.
March 15, 1970	(1) Make project computer runs. (2) Verify with control totals. (3) Make and verify connections.
April 1, 1970	Make additional computer runs as necessary.
April 15, 1970	Submit completed program to Regional Forester.

B. Measuring Changes in Outputs

The primary effect of a forest land treatment practice is usually predictable and quantifiable but very often a host of secondary effects are unknown or ignored. For example, it is possible to estimate the volume of wood that should result from a tree planting job but the long time effects on water production, recreation, grazing capacity and wildlife numbers are seldom evaluated quantitatively.

It has always been assumed that these effect would be or could be quantified as a result of research progress. While much has been learned, not much is directly transferable to an individual project because of the inherent variability of nature. It is now apparent that for a specific project, we must rely on inferences assumptions and experiences to quantity outputs.

The environmentally-minded manager wants to be aware of all the effects that will be triggered by his proposal. This requires estimates for all outputs. To do this, work plans must specify the physical characteristics, land use zone, present land condition, proposed treatment and work method. Secondary output changes, sometimes quite small, are often the significant ones in evaluating alternate project choices.

Outputs become available and usable at different times. Some are usable upon completion of the project, others are usable only many years in the future - some build up to a peak while others begin to decay immediately.

Outputs may also be incremental, i.e., they add or detract from things already being produced. They may change in value or quality but in quantity remain the same. Then there are outputs that have no present or favorable benefits or disbenefits. This kind is often due to lack of demand in that local area. Such "useless" outputs are best left out of consideration if their effect is essentially neutral. This brings us to the "distributed" output concept which says "consider only those outputs that will be available to and are needed by the consuming public or other governmental units." This might be interpreted as including only the positive or beneficial effects, leaving out the disbenefits. The disbenefits or negative effects are often

controlled by specifying the amount that will be tolerated for a class of project work, e.g., a control statement to the effect that soil erosion potentials must be no greater after the project is completed than it was in its undisturbed condition. This, of course, is not always possible and a listing of the dis-benefits is often useful, especially if the forest has established tolerance levels for these negative outputs.

We shall confine this discussion to actual effects. Relative rating schemes are useful in the absence of data but comparable ratings between classes of projects are almost impossible to devise, and they are of little help in deciding if the project contributes much in absolute values to the forest goals.

OUTPUTS AND THE ELDORADO STUDY

The list of outputs in this section was devised for one national forest - the Eldorado in Region 5.

1. *Timber Growth:* *Thousand board feet per acre per year. Since growth response is frequently delayed for one or more years after treatment, the values should represent the average response over a five year period.
2. *Timber Cut:* *Thousand board feet per acre as determined from surveys or estimates. Roundwood cut should be converted to board feet with standard converting factors. Time period - 1 year.
3. *Timber Regeneration:* *Thousand board feet per acre per year. While number of acres regenerated has value, a volume measure more adequately will convey differences of sites and species. The measure can only be the potential growth per acre per year for the rotation since newly regenerated stands will not have any measurable growth for many years. This is consistent with timber management plans for national forest. Time period - Rotation.
4. *Livestock Grazing:* Animal unit--months. This is cattle and horse use, for sheep use the 1 to 5 conversion

*Note: Timber measures in cubic feet will replace the board feet measure as soon as local conversion factors become available.

factor. The AUM is also used by the Forest Service as the basis of range fees. The forage made available or lost must be on usable range or adjacent to it. Time period - 5 years.

5. *Wildlife Browsing:* Animal unit months of deer forage applied only to critical deer range. Time period - 5 years. Eventually we will have to recognize other wildlife outputs in the small game and fish categories, such as acres of habitat created or improved.
6. *Water Runoff:* Acre feet of water per acre reaching the stream channels. Time period - 5 years.
7. *Soil Stability:* Acres in these two classes:
   a. Project acres on which soil is disturbed so that mineral soil will be exposed for more than one year.
   b. Project acres on which productive capability is restored.

Time period - 2 years. Measurements of volumes or weights of soil losses or soil saved would be alternate measures if reliable data can be found. It is now a requirement of all Forest Service project work that accelerated erosion must be controlled when the project is completed.

10. *Recreation Visitor Days:* There are specific types of Recreation Visitor Days that would be of value in decision making.
    10A. Fishing days
    10B. Hunting days
    10C. Camping or picnicking days
    10D. Scenic travel days
    Time period - 2 years
13. *Accessibility:* Measure of acres in which attack time is changed from one hour control class to another seems to be adequate. Time period - 1 year.

About half of the projects in the Eldorado final F. Y. '69 program had no direct, measurable outputs.

Some examples are: maintenance of buildings, etc; capital investments such as buildings; pre-suppression; cattle guards; surveys, analyses, examinations, studies, plans. One reason was lack of data (including future outputs). These projects must still be included in the computer runs because they use manpower skills which must be allocated. As the examples above show, there is still considerable work to be done to "pin down" useful output definitions for each activity.

NATIONAL FOREST WORK CATEGORIES

SHOWING OUTPUTS COMMONLY ASSOCIATED WITH PROJECTS IN EACH CLASS

		PROJECT TYPE										
	OUTPUT	Timber Harvesting (Final or Regeneration Cuts)	Reforestation	Timber Stand Improvement (Include Intermediate Cuts)	Disease & Pest Control (Acres Treated)	Roads & Trails Cons't	Increase in Recreation Capacity	WRDRA Jobs	Wildlife Habitat Imp.	Fuel Modification	Soil & Water Projects	Range Imp. & Revegetation
1	Timber Growth	O	O	X	X	X	X	X	X	O	X	X
2	Timber Cut	X	O	X	X	X	X	O	X	O	O	O
3	Timber Regeneration	X	X	O	X	X	O	X	X	X	O	X
4	Livestock Grazing	X	X	O	O	X	X	X	X	X	X	X
5	Wildlife Browsing	X	X	X	O	X	X	X	X	X	X	X
6	Water Runoff	X	X	X	O	X	O	X	X	X	X	X
7	Soil Stability	X	X	X	O	X	X	X	X	X	X	X
8	Water Quantity	X	X	X	O	X	X	X	X	X	X	X
9	Recreation Enviornment	X	X	X	X	X	X	X	X	X	O	O
10	Recreation Visitor Days	O	O	O	X	X	X	X	X	O	O	O
11	Fire Hazard Reduction	X	X	X	X	X	X	X	X	X	X	X
12	Fire Risk Reduction	X	O	X	X	X	X	O	X	O	O	O
13	Fire Accessibility	X	O	O	O	X	X	O	O	X	O	O

X - This type of project will usually produce a significant amount of the output indicated

O - Very little or no effect

EXHIBIT 3

NUMBER OF OUTPUT COEFFICIENTS NEEDED FOR ELDORADO PPB - 1969

OUTPUT	CLASS OF WORK*															
	1	2	3	4	5	6 & 7	8	9	10	11	12	13	16	17	Total
1 Timber Growth	0	6	6	6	6	0	0	6	6	1	0	1	1	0	39
2 Timber Cut	6	6	6	0	0	0	0	0	0	1	0	0	1	0	20
3 Timber Regeneration	6	6	6	0	0	6	6	0	6	0	0	0	1	0	37
4 Livestock Grazing	6	0	0	0	0	6	0	0	0	1	8	4	2	0	27
5 Wildlife Browsing	6	6	6	6	6	6	6	0	0	1	8	3	2	0	56
6 Water Runoff	6	6	3	5	0	5	5	5	0	0	6	3	3	0	47
7 Soil Stability	9	9	9	9	9	18	9	9	0	1	3	4	4	1	74
8 Water Quality	9	9	9	9	9	25	9	9	0	2	2	4	4	1	101
9 Rec. Environment	6	6	0	6	6	6	6	6	0	3	7	4	5	5	66
10 Rec. Visitor Days	6	0	0	0	0	0	0	0	0	0	3	0	7	7	23
11 Fire Hazard Reduction	6	6	6	6	6	6	6	6	0	3	0	2	3	1	57
12 Fire Risk Reduction	6	6	6	6	6	0	0	0	0	2	0	0	4	0	36
13 Fire Accessibility	6	6	6	6	6	6	6	0	0	1	0	0	4	1	48
	78	72	63	59	54	84	53	41	12	16	37	25	41	16	651

*Classes of work recognized, 1969

1. Regeneration cuts
2. Intermediate cuts, non-modified
3. Intermediate cuts, modified areas
4. Precommercial thinning, non-modified
5. Precommercial thinning, modified areas
6. Site preparation, timber regeneration
7. Site preparation, trenching or contour, travel influence zone
8. Site preparation, trenching or contour, distant view management
9. Seed, plant or slash disposal for natural regeneration
10. Plantation protection
11. Recreation cons't and maint.
12. Range improvements
13. Water resource development
14. Building maintenance
15. Eng. Survey & design
16. Road & trail construction
17. Road & trail maint.
18. Impact surveys
19. Miscellaneous

Workclasses 14, 15, 18 & 19 outputs are not measured in resource terms.

EXHIBIT 4

AN EXAMPLE OF COEFFICIENT DEVELOPMENT FOR TIMBER REGENERATION (GROWTH)

An actual timber regeneration(growth) output is indicated for projects in these categories: Regeneration Cuts, Seeding and Planting Trees, Rodent Control in Timber Stands, Campground Construction, and Road and Trail Construction. The tables below have been compiled from estimates given by the R-5 Branch of Silviculture and PSW Research Note #104 of April 16, 1956, "Planting Ponderosa Pine is a Good Investment." These values were adjusted for other types by growth rates as suggested by R-5 Branch of Silviculture. No values are shown for Site 5 as this site class is not considered in R-5 timber management plans.

GROWTH IN BD. FT. PER A. PER YEAR
(FULLY MANAGED STANDS)

Timber Type	SITE CLASSES					
	1A	1	2	3	4	5
PP-R5	1800	1500	1000	800	300	-
PSW#104	1830	1250	770	480	250	-
Av	1815	1375	885	640	275	-
W.F.1.58	2870	2170	1400	1010	435	-
D.F. .89	1615	1220	790	570	245	-
M.C.1.12	2030	1540	990	720	310	-
R.F.1.71	3100	2350	1510	1095	470	-

EXHIBIT 5

AN EXAMPLE OF COEFFICIENT DEVELOPMENT FOR TIMBER STAND IMPROVEMENT

LAND TREATMENT EFFECTS ON TIMBER GROWTH
(THINNINGS & INTERMEDIATE CUTS)

Site Class	Rotation Age	*No. Treatments	Managed Yield	Normal Yield	Increased Yield	Increase Per Year	Increase Per Treatment (Ponderosa Pine)	White Fir	Douglas Fir	Mixed Conifer
1A	80	2	147895	66500	81395	1020	510	800	450	570
1	80	2	100310	43900	56410	700	350	550	310	390
2	80	2	61250	26000	35250	440	220	350	200	250
3	100	3	47550	19700	27850	280	90	140	80	100
4 & 5	140	5	34105	16700	17405	120	24	38	21	27

EXHIBIT 6

*Thinnings and Intermediate Cuts are assumed to have equal effects. Managed and normal yields are for Ponderosa Pine, values for White Fir, Douglas Fir and Mixed Conifer have been obtained by factors of 1.58, 0.89 and 1.12.

C. A Summary of Joint Outputs for the F.Y. 1970 Project Bank

The Appendix of the first report of this series, entitled "An Overview of a Study in Program Budgeting on a National Forest" contains a brief discussion called "Verifying the Assumption of Joint Multiple Outputs." What follows herein is a more complete exposition of the matter. In particular, we show here the same sort of charts using a finer breakdown of functional inputs and we report relative as well as actual outputs. The first two charts show the values used in computing the second two charts. The latter charts show output percentages. In these charts note that the Lake Tahoe Sewer Project is included. (It was excluded from the charts in the first report.) Data is for the F.Y. 1970 Project Bank. Relative outputs tell use about soil stability, water quality, recreation environment and fire hazard reduction--items not included in tables of actual outputs because of our inability to develop appropriate units of measure for them. The charts indicate, in the opinion of the author, that joint multiple outputs characterize in large part the activities of the Eldorado. Hence the assumption which led to the linear programming formulation is valid.

Exhibit 7

	P & M											K.V.		WRDRA		BR DISP	F R & T MAINT.		F R & T CONSTRUCTION				TOTAL
	031	033	034	051	052	053	070	080	092	101	110	033	034	070	092	031	121	140	132	133	134	150	
Timber Growth MMBF	1.008	.19	.096									.267	.36										1.926
Timber Cut MMBF	150.5																						150.5
Timber Regeneration Growth MBF	699.5						-4.5		31			238.2		-2.1					26	-268	-6.2	-31	682.9
Wildlife Grazing AUM	198.2		19.3			.4	.2	.6				84.8	23.8						6			3.1	336.4
Water Runoff M. ACF. FT.	1.1		.1									.1											1.3
Productivity Restored ACRES	-15.2								17.4										-44.2	-231		.21	-294.0
Fisherman Days VIS. DAYS	232				.5		1473							855							3845		6405.5
Hunter Days 1000 VIS DAY	2.79						.13	.001	.023			1.3		.85		.021			.03		3.84		9.01
Livestock Grazing AUM				6	4																		10.0
Camping & Picnicking VIS DAY							3767							8550							38450		50767.0
Scenic Travel 1000 VIS DAYS							1623					-1.4		2137		-1.1					9612		13370.5
Fire Accessibility ACRES																			797	7230			8027
n Vis- .000's)							3035			15.7				9.4			1.5				7.1		3069

TOTAL MULTIPLE OUTPUTS (actual in physical units)

	P & M											K.V.		WRDRA		BR DISP	F R & T MAINT.			CONSTRUCTION			TOTAL
	031	033	034	051	052	053	070	080	092	101	110	033	034	070	092	031	121	140	132	133	134	150	
Timber Growth	4409.7	3200.9	308				-21					3455.2	1013.5	-8.6	1				-44.8	-231	-38.5	-20	12,024.4
Timber Cut	2049.9						8.7							2.6					44.8	175	11.5	20	2,312.5
Timber Regeneration	428.9								47			928.5			1	15.9			27.2	-199		-16	1,233.5
Livestock Grazing	7.8			18	24	3			12						.4		9.8						75.0
Wildlife Grazing	779.6		77			.8	.2	1				127.2	93.6				9.8		38.8	5.6		31	1,164.6
Water Runoff	1526.2		115.5	18	24		2.4	-.3	-23.3	.1	.9	451.1	358.7		-1	10.8	583.4	26.2	20.8	231		23	3,368.4
Soil Stability	-620.9						-.2		2.4		8.1	-297			2	-4.2	3339.3	267.7	-13.2	-46.2		118.6	2,756.4
Water Quality	-620.2						608.4		1.9	9.2	10.1	-297			2	-4.2	2093.3	43.7	-3.3	-12.3		11.4	1,843.0
Recreation Environment	297.5	200.3		6	12	2	2542.8	1	41.9	23.6	10.2	638.7	48.6	13.1	1	21	1748.1	373.5	86.8	231	38.5	88.9	6,426.5
Recreation Visitations	23.2				1		2525.9	.3		21.6	17			9.5			2099.5	379	44.8	231	38.5	83.9	5,475.2
Fire Hazard Reduction	-1382.7						615.9		-14.1	30.3		528.4	-44.4	.9		10.8		37	-13.5	23.1	3.8	8.1	-196.4
Fire Accessibility																			818.8	5895			6,713.8

JOINT MULTIPLE OUTPUTS (relative effects)

Exhibit 8

Exhibit 9

	P & M											K V		WRDRA		BR DISP	F R & T MAINT.		F R & T CONSTRUCTION				TOTAL
	031	033	034	051	052	053	070	080	092	101	110	033	034	070	092	031	121	140	132	133	134	150	
Timber Growth M. B. F.	52	10	5									14	19										100
Timber Cut M. B. F.	100																						100
Timber Regeneration M. B. F.	101						-1	5				35		*					4	-39	*	-5	100
Wildlife Grazing A. U. M.	60		6			*	*	*				25	7						2			*	100
Water Runoff M. ACF. FT.	84		8									8											100
Productivity Restored ACRES	5								-6										15	79			100
Fisherman Days VIS. DAYS	4				*		23							13							60		100
Hunter Days VIS. DAYS	30						1	*	3			15		9		*			*		42		100
Livestock Grazing A. U. M.				60	40																		100
Camping and Picnicing VIS. DAYS							7							17							76		100
Scenic Travel VIS DAYS							12					*		16		*					72		100
Fire Accessibility ACRES																			10	90			100
Recreation Visitation VIS. DAYS						*	100			0				*			*				*		100

JOINT MULTIPLE OUTPUTS (actual, in %)

	P & M											K V		WRDRA		BR DISP	F R & T MAINT.		CONSTRUCTION				TOTAL
	031	033	034	051	052	053	070	080	092	101	110	033	034	070	092	031	121	140	032	133	134	150	
Timber Growth	36	27	3				*					28	8	*	*				*	-2	*	*	100
Timber Cut	89						*							*					2	8	*	1	100
Timber Regeneration	35								4			75			*	1			2	-16		-1	100
Livestock Grazing	10			24	32	4			16						1		13						100
Wildlife Grazing	67		7			*	*	*				11	8				1		3	*		3	100
Water Runoff	45		3	1	1		*	*	-1	*	*	13	11		*	*	17	1	1	7		1	100
Soil Stability	-23						*		*		*	-11			*	*	122	10	*	-2		4	100
Water Quality	-34						33		*	*	1	-16			*	*	114	2	*	-1		1	100
Recreation Environment	5	3		*	*	*	40	*	1	*	*	10	1	*	*	*	27	6	1	4	1	1	100
Recreation Visitations	*				*		47	*		*	*			*			38	7	1	4	1	2	100
Fire Hazard Reduction	703						-314		7	-15		-269	23	*		-5		-19	7	-12	-2	-4	100
Fire Accessibility																			12	88			100

JOINT MULTIPLE OUTPUTS (relative, in %)

D. Constraints to Insure Feasibility

In this section we discuss how constraints facing a manager should be reflected in all PPB models and how the Annual Budget Model does this at the forest level.

1. Relationship between Constraints and Feasible Programs

If a project (or proposal) contains information on manpower, cost, function, time, outputs, and administrative units it is desirable that a planning model also do so. But a decision maker must also deal with constraints and objectives which cut across units, time, function, outputs and manpower. For example, the Eldorado Forest Supervisor chose for F. Y. 1969 to consider: forest-wide, not district-wide, constraints on money and outputs. But next year he recommended individual district-wide constraints on manpower also.

The kind of constraints facing a Regional Forester are likely to be different than those facing a Forest Supervisor. For example, the region may be concerned with total manpower, whereas the forest is concerned with skills as well. This means that a regional allocation proposal, satisfying only total manpower, can be infeasible at individual forests because of the manpower skills required.

2. Features of the Annual Budget Model

The model is flexible--neither constraints nor reports are automatically incorporated; on the contrary, the user specifies them. For example, he may set an upper bound on an individual appropriation or instead he may set both upper and lower bounds to allow the level to fluctuate between them. He may also set the level exactly so that all the funds are used up. Finally, he may set only a lower bound (minimum level). Similar remarks hold for functional totals or combinations of functional-appropriation totals. The same remarks hold for: outputs, functional funds, projects or contributed time in any combination. He may receive reports on these and on:

a. Manpower needed, short or surplus

- by skill
- by season
- by district or forest-wide

b. Sub-unit budget breakdown by appropriation

c. Forest-wide units of work e. g., miles of fencing or acres treated. (With present definitions of accounting activity codes these reports will be unreliable.)

Future cost implications on the project input sheet may be reported if the user requests it. (Provisions include costs for five years and recurrent costs.) Related projects are tied together by specifying those which are members of the group.

Outputs are entered two ways: either on the project input sheet or on a table previously stored in the computer. (The user governs because if both are used, the input sheet value *over-rides* the table value.) The user need only code the project by land characteristics, land treatment and work method--an attempt at a universal way of relating projects to outputs for service-wide use.

The model is reversible--it may be used for either proposing future work or for allocating existing funds.

In our experience with Eldorado F. Y. 1969 and 1970 budget runs, it was never necessary to constrain any parts of the manpower network, i. e., shortages, excesses or hours required. Hence in developing the final version, we assumed this would continue to be true. Instead, the Supervisor considered the distribution satisfactory if (1) total shortages and excesses were roughly equal and (2) excesses are of higher orders of skill than shortages. When the distribution was unsatisfactory, he was reluctant to specify how to constrain it to achieve a satisfactory solution. Instead, he selected an alternative program from the array. This led us to conclude that manpower distribution could be computed separately after projects are selected. Decomposing the original problem, in this way, still permits us to include constraints on manpower used by skill by season by sub-unit as part of the model. (When this is done, the size of the linear programming matrix

is not excessive because the matrix generator writes equations only for actual constraints needed for each problem.)

The scheme we evolved is as follows: solve for best project mix with money, output and manpower used as constraints; then the manpower used become the "demands" for the manpower distribution problem, which is solved independently using a network flow algorithim.

E. The Man-hours by Skill by Season Required for the F.Y. 1970 Program

The purpose of reporting manpower is to provide the supervisor with information on the feasibility of each program on two counts: first on whether his people are financed, and second on whether the manpower skills available are sufficient to carry out a proposed program. The categories were chosen by the forest.

The first table which follows shows the total manhours for each skill required to carry out the Eldorado F.Y. 1970 Annual Program. The second table which follows shows these skill-hours by season. (The codes are included as reference for examples in the October 1, 1968 memorandum which follows these tables.) The field season runs from May 1 through October 31 for the Eldorado.

Code	Title & Hours	Description
01	Management Supervision 33,716 Hours	Work normally performed by the District Ranger or some individual of adequate experience to represent the District Ranger. It is not the project foreman.
03	Professional Forestry 37,591 Hours	Work of a professional forester, usually a graduate forester. In some exceptional cases, technical personnel are included in this category.
05	Timber Technician - Specialized 18,560 Hours	Permanent people with considerable experience who are capable of performing foreman duties under the intermittent supervision of the Ranger or his principal staff; for example, the foreman of a stand improvement crew.
07	General Forestry Tech. Labor 23,437 Hours	Permanent people of minimum experience in forestry, but above the labor category; for example, the foreman of a stand improvement crew.

Code	Title & Hours	Description
09	Laborers 17,109 Hours	Largely manual tasks with constant or near-constant supervision. Requires no education or experience.
11	Fire - Specialized 18,079 Hours	Requires so much education, experience, and/or continuity that we use PFT appointments to hire these skills.
13	Fire - Technical 23,568 Hours	People hired on a seasonal basis.
15	Range - Specialized 936 Hours	Requires so much education, experience, and/or continuity that we cannot generally hire temporary help for this category.
17	Range - Technical 32 Hours	Laborer cannot be expected to do this work, but we hire temporary help who can do it.
19	Wildlife - Specialized 1,104 Hours	Requires experience, education, and/or continuity which we can get only from PFT positions.
21	Wildlife - Technical 0 Hours	Laborer cannot be expected to do the work, but we hire capable temporary people.
23	Soil and Water - Specialized 3,644 Hours	Requires enough education, continuity, and/or experience so that PFT people should do it.
25	Soil and Water - Technical 392 Hours	Work can be done by seasonal employees, but is not all manual labor.
27	Recreation - Specialized 3,106 Hours	Demands education, continuity, and/or experience; done by PFT personnel.
29	Recreation - Technical 17,912 Hours	Seasonal employees. If no public contact is involved, the Laborer category (09) is more accurate and should be used.

Code	Title & Hours	Description
31	Landscape Architect 4,822 Hours	Work requiring a formally educated landscape architect; temporary or permanent.
33	Geneticist 3,488 Hours	Work requiring a formally educated geneticist; temporary or permanent.
35	Scalers 5,976 Hours	Certified scalers; forester or other.
37	Engineering - Supervision 9,274 Hours	The equivalent, in Engineering, of Management Supervision; generally assigned to the Forest Engineer or his principal assistants.
39	Engineering - Design Specialized 14,013 Hours	Ability to produce finished designs from survey data.
40	Engineering - Design - Technical 2,779 Hours	Translates data to scaled plans under the supervision of a Design Engineer.
41	Engineering - Survey - Specialized 14,491 Hours	Party Chief or equal.
42	Engineering - Survey - Technical 25,689 Hours	A crew member of limited experience, not capable of doing a survey by himself. Generally a temporary employee.
43	Engineering - Contract Admin. 17,458 Hours	Only engineers administering contracts. District Ranger would use 01 for administering engineering contracts.
45	Construction and Maintenance 21,268 Hours	An individual, temporary or permanent, experienced in C & M work.
47	Radio Technicians 3,120 Hours	Diagnose and repair any deficiency in the radio net.
49	Equipment Operators 5,604	Temporary or PFT, qualified or licensed to operate equipment.

Code	Title & Hours	Description
51	Mechanics 0	Major or complicated repairs on vehicles. Generally limited to WCF mechanics.
53	Supervisor and Staff 12,744 Hours	Limited to Forest Supervisor and his principal staff.
55	Accounting and Support 72,154 Hours	Forest Administrative Services people and District Clerks.
57	District A. A. 4,210 Hours	Self-explanatory.
59	Job Corps Supervision 0	Job Corps salaried employees.
61	Job Corps Trainee 0	Corpsmen only.

Note: Some categories (e. g., Mechanics) show zero hours required. This is because no individual PWP's were made for their work not because there were no work required.

MANHOURS BY SKILL BY SEASON REQUIRED FOR THE F. Y. 1970 PROGRAM

Skill	Field	Other	Either	Contributed
Management Supervision	15,705	10,857	6,954	200
Professional Forestry	22,369	9,011	6,195	16
Timber Technician-Specialized	10,294	4,084	3,718	464
Fire-Specialized	14,640	2,625	814	0
Range-Specialized	600	336	0	0
Wildlife-Specialized	600	504	0	0
Soil and Water-Specialized	1,712	1,692	240	0
Recreation-Specialized	772	534	1,800	0
Landscape Architect	2,040	60	2,722	0
Geneticist	520	0	2,968	0
Scaler	5,241	735	0	0
Engineering-Supervision	3,068	1,696	4,510	0
Engineering-Design-Specialized	3,246	3,731	7,036	0
Engineering-Design-Technical	0	1,259	1,520	0
Engineering-Survey-Specialized	6,948	0	7,551	0
Engineering-Contract Administration	12,618	3,360	1,480	0
Construction and Maintenance	9,875	5,504	5,573	416

Skill	Field	Other	Either	Contributed
Radio Technicians	788	1,800	532	0
Equipment Operator	3,924	1,472	208	0
Mechanic	0	0	0	0
Supervisor and Staff	722	526	11,496	0
Accounting and Support	68	508	71,578	0
District A.A.	1,648	1,294	1,268	80
Job Corps Supervision	0	0	0	0
Job Corps Trainee	0	0	0	0
General Forest Technician	13,411	1,270	4,944	3,812
Laborer	13,274	1,485	550	1,800
Fire-Technical	22,808	544	0	216
Range-Technical	32	0	0	0
Wildlife-Technical	0	0	0	0
Soil and Water Technical	0	32	280	80
Recreation-Technical	15,755	1,469	228	460
Engineering Survey-Technical	18,397	0	7,292	0

III. PROGRAM BUDGETING AND OVERHEAD DISTRIBUTIONS

In this section we raise questions about conflicts between output-oriented budgeting and the traditional methods of handling general administrative expense distributions. We do not request general expense funds from Congress, hence each appropriation must bear a "fair" share of administrative expenses. This is important because the choice of projects depends on how fixed costs are distributed to appropriations. The sums involved are not small. For example, the Eldorado required about $0.8 million for general administrative expenses for F. Y. 1969 or about 17% of its normal annual $4.7 million budget(excluding the Tahoe Sewer Project).

Four philosophies of "fair" share come to mind. First, *distribute in proportion to available appropriations.* "Fair" share means proportional to amounts of money allotted. Second, *distribute in proportion to the workload impacts.* "Fair" share means proportional to the expected man-hours or salaries of each functional program. (Bob Ground, R-5 Budget Officer tested this on data for two forests.) Third, *soak the rich.* Fair share means smaller functional funds contribute less in proportion than larger funds such as P&M and FR&T. Fourth, *optimize our programs.* This means develop the best programs and let the distribution fall where it may. This requires a policy of flexibility to shift funds between appropriations. (Current policy permits some flexibility and may be used advantageously whenever allocations do not *exactly* match any of the original alternative proposals.)

Suppose that forest general administrative expenses were lump-sum funded by the Regional Office. Then a functional program for, say, regeneration would be rather independent of other programs because its size would have little effect on the size of other programs except for manpower. With such a scheme, we could develop proposed "packages" of projects, *within* a function or appropriation, largely independently of other "packages". This is easy for proposals made in advance because general administrative expenses would be added only at the final step after all functional "packages" are submitted.

But afterwards, during the allocation phase, this would not be so easy because forest projects would compete for the *remains* of appropriated funds only *after* general expenses have been distributed.

Based on our observations of the F. Y. 1969 and 1970 Eldorado proposals, we can infer that some minor shifts in overhead distributions result in a marked increase in some important outputs. This points out that output-oriented budgeting conflicts with our current fixed-cost distribution philosophies. Hence, we feel these should be reviewed.

IV MODELS FOR OPTIMAL PROJECT SELECTION AND MANPOWER ALLOCATION

A. The Concept of Land Management Activities

An "activity" is something we do on a designated land area which costs money and eventually contributes directly or indirectly to one or more physical outputs. For example, timber harvesting and range seeding directly produce quantifiable outputs. But such activities as disease and insect control, fire prevention and suppression, and erosion control protect resources and result in future outputs. And resource surveys and road engineering enhance our ability to manage the resources but do not produce direct physical outputs.

Many land management activities are intrinsically interrelated either by the laws of nature or by the way we are organized to manage. For example, harvesting timbers means that water run-off changes, the inventory of timber decreases, wildlife habitat changes, etc. Cruising and marking must be done long before harvesting begins, and thus future activities must be coordinated with current activities. Also, the usable output of an activity such as planting is not realized at the time it takes place.

Changes in goals and policies can be explored systematically by changing the constraint levels. The final selection of output and policy goals rests with the land managers and Congress, who must weigh the socio-economic and political impact of their decisions. The model itself simply processes information, bringing into focus the ecological, economic and organizational consequences of alternative decisions.

B. The Linear Programming Formulation

Briefly, the model is formulated in terms of linear programming; that is, minimize a linear form subject to a system of linear constraints in which the variables are land management activities that result, ultimately, in multiple outputs.

Each column of the coefficient matrix is a vector, the components of which represent the results of engaging in the corresponding activity. The results are in such terms as:

physical outputs (immediate or future), costs, impact on other activities, and impact on policies. We assume that the results are additive and that inputs and outputs are proportional to activity level and finally, that activity levels are non-negative quantities.

The objective function chosen corresponds to the kind of question being investigated. Briefly, the possibilities considered are:

1. For a fixed, multiple-output level, activities are operated so as to minimize "out-of-pocket" costs.
2. For a fixed budget, activities are operated so as to maximize total benefits.
3. For a fixed budget, activities are operated so as to maximize output levels (usually one output at a time).

We represent each project by a column of numbers, listing the required inputs and outputs. For example, suppose the project is to plant 100 acres in trees on sub-unit A at a cost of $2,000 the first year and $200 the second year. The listing of the inputs and outputs might be as follows:

Outputs	Water Runoff	61	Acre Feet
	Forage Capacity	3	A. U. M.
	Timber Growth	8000	Cu. Ft.
Inputs	Prof. Forester	10	Hrs. field season, sub-unit A
	Forestry Technician	30	Hrs. field season, sub-unit A
	Laborer	260	Hrs. field season, sub-unit A
	Acres planted	100	
	Charge: Function 033	$2,000	
	Charge: Appropr. P&M	$2,000	
	2nd Year Cost	$ 200	

Note: Cost appears for both "function" and appropriation. Also, the future cost implication ($200) appears explicitly. In this example, an output refers to the average value over the time period for which the increase (or decrease) applies. A different time period is usually used for each output. It is a straightforward proposition to extend the output listing so as to reflect the changes in outputs as they occur from year to year. (The difficult part is to measure output changes as a function of time.)

In mathematical terms, let:

x_j = level of project j

b_j = bound on outputs (or inputs)

a_{ij} = i^{th} output (or input) coefficient of the j^{th} project

c_{ij} = i^{th} cost coefficient of the j^{th} project

Note that: $0 \leq x_j \leq 1$ for all j is usually assumed.

To illustrate, suppose we have two sub-units, A and B, with 3 projects each. Suppose we have three outputs, two functions, one appropriation, two skills and one season. Suppose we wish to constrain appropriations, functions, outputs, manpower used per sub-unit, and we wish to minimize total cost.
The layout is as follows:

Sub-unit A			Sub-unit B				
X_1	X_2	X_3	X_4	X_5	X_6		
a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	$= b_1$	1st output
a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}	$\geq b_2$	2nd output
a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	$= b_3$	3rd output
a_{41}	a_{42}	a_{43}				$\leq b_4$	Hours sub-unit A, skill 1
a_{51}	a_{52}	a_{53}				$\leq b_5$	Hours sub-unit A, skill 2
			a_{64}	a_{65}	a_{66}	$\leq b_6$	Hours sub-unit B, skill 1
			a_{74}	a_{75}	a_{76}	$\leq b_7$	Hours sub-unit B, skill 2
c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{16}	$= \$_1$	1st type of cost
c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{26}	$\leq \$_2$	2nd type of cost
c_{31}	c_{32}	c_{33}	c_{34}	c_{35}	c_{36}	= minimum (Total cost)	

j = 1,2,3 for sub-unit A

j = 3,4,5 for sub-unit B

i = 1,2,3 for outputs 1,2,3

i = 4,5 for manhours skill 1,2, for sub-unit A

i = 5,6 for manhours skill 1,2 for sub-unit B

Now suppose we wish to solve a type II problem, say, maximize the 1st output. Then the layout is the same as before except that the 1st row (excluding b_1) is substituted for the last row (total cost) and the instruction changes from minimize to maximize.

C. Output Values and Effectiveness Measures

In this section we discuss why output values in the public sector are hard to define, what measures of program effectiveness may be used and how the approach we have adopted may be used with or without explicit output values.

One problem associated with determining output values in the public sector is the publicness of the decisions made. Public intervention is required when there are substantial third party benefits (for example, education provides benefits beyond those directly received by the recipient). Government intervenes when production implies an indirect social cost (for example, pollution control). Public intervention is done to establish a technical monopoly, subsidizing some commodities to keep the price low. The Government has also intervened in the private sector when the time preference for individual operators is too short to adequately weigh the inter-temporal values of resources, the use of which straddles several generations.

Another related problem is the lack of data for traditional investment decision. Traditionally, decisions based on economic analysis use costs and returns. But the lack of measures of values means lack of hard measures for returns on investments.

There are many different kinds of value methods. For example, exchange value (market value); consumer value (a willingness to pay): producer value (the cost to produce); increasing gross national product: monopoly revenue value; and expenditure value. These six different value methods are defined by Whaley (5). He also points out that a value "system" must meet the following criteria: (1) it must be appropriate for the model; (2) it must achieve comparability across-the-board for *all* outputs (the same method for achieving values must be used for all outputs); and (3) the values must be empirically quantifiable. The point is that since so many different kinds of values exist, the absence of a value system means the choice of method for valuing outputs can be rather

arbitrary.

To date, such a value system does not exist. Developing one for the Forest Service lies in the realm of a specialized field of economics. We felt that the task of developing a value system lies outside the scope of the Management Sciences Staff and the PPB project in particular.

What is the basis for decision in the absence of output values? Again Whaley (5) lists four measures of program effectiveness which may be used in public resource management. One is to meet established production goals at least cost. Another is to establish the budget level and maximize some outputs. Another is to claim that no rational solution exists. (We don't make this claim!) The fourth is to maximize economic development. *The Annual Budget Model is designed for using any of these.* Therefore, when values for outputs are developed (by any value system that meets the criteria already discussed) they can be easily employed as a measure of effectiveness in the objective function of the model. Incorporating output values is straight forward and a simple matter to use as we illustrated in the previous Section A of this report.

In the meantime, implicit subjective values may be the only values which a Forest Supervisor has. But, he still needs alternative programs from which to choose and implicit values are still useful in choosing the best program.

The table which follows shows a few of the different problems that one could solve using the model. It shows a variety of constraints and objective functions which can be used. Note that one of the objective functions is *maximize total benefits* where the *benefits* are any values (either purely relative or absolute), such as present net worth, internal rate of return, increase in GNP, etc.

COMMON PROBLEMS FOR THE FOREST ANNUAL BUDGET MODEL

Problem Number	Specify Individual Appns. or Functional levels as:	Specify Individual Output levels as:	PROGRAM EFFECTIVENESS MEASURE		
			Least Cost	Max. Output*	Max. Total** Benefit
1	maximum	minimum	x		
2	unconstrained	minimum	x		
3	fixed	minimum	x		
4	fixed	unconstrained	x		
5	maximum	minimum		x	
6	unconstrained	minimum		x	
7	fixed	minimum		x	
8	fixed	unconstrained		x	
9	maximum	minimum			x
10	unconstrained	minimum			x
11	fixed	minimum			x
12	fixed	unconstrained			x

*Usually a succession of outputs would be chosen; however, with fixed ratios between outputs a "bundle" of outputs can be maximized.

*e. g., dollar values, proxy values, inputed values, etc.

The Forest Supervisor chose problem Number 8 for F. Y. 1969 proposals, and 50 alternatives were generated, ten of which constrained only total budget and a few functions.

EXHIBIT 12

D. Marginal Values (Shadow Prices)

The notions of marginal analysis of classical economics are intuitively appealing and it is not uncommon to find suggested uses in the literature for an economic problem formulated in terms of linear programming. Each final solution yields a set of values, often called "Shadow-Prices" which are marginal values. Using these values for marginal analysis depends on their interpretation and the nature of the problem itself.

We seriously considered this as early as 1966. But no one problem uniquely defines the conditions as seen by a manager. Hence there are difficulties in interpreting the meaning of shadow prices for a sequence of problems. In addition for each problem there is a set rather than a single shadow price for each output, as we will illustrate.

Consider the following linear programming problem:

X_1	X_2	X_3	X_4	X_5	X_6			
a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	=	b_1, 1^{st}	output
a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}	$\geqq$	b_2, 2^{nd}	output
a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	=	b_3 3^{rd}	output
c_{11}	c_{12}	c_{13}	c_{14}	c_{15}	c_{16}	=	b_4, 1^{st}	type of cost
c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{26}	$\leqq$	b_5, 2^{nd}	type of cost
c_{31}	c_{32}	c_{33}	c_{34}	c_{35}	c_{36}	=	minimum (Total Cost).	

This is the same layout as the one in Section A except for the omission of constraints on manpower.

Now suppose $\bar{X}_1$ $\bar{X}_2$,..., $\bar{X}_6$ solves the problem. Let the corresponding optimal simplex multipliers ("shadow prices") be π_1, π_2, ... , π_5. Note that π_1, π_2 and π_3 correspond to output constraints whereas π_4 and π_5 refer to money constraints. We see that there is a "shadow price" for each constraint. Let us verify the units of measure of these "shadow prices". At optimality, by the theorems of duality, we have that

$$\pi_1 b_1 + \pi_2 b_2 + \ldots + \pi_5 b_5 = c_{31} \bar{X}_1 + c_{32} \bar{X}_2 + \ldots + c_{36} \bar{X}_6.$$

The units of measure, term by term must be equivalent.

But $c_i \bar{X}_i$ is dollars for all i = 1, 2,...6; hence $\pi_j b_j$ must also be dollars for all j = 1, 2, ...5. But the units of measure for b_j, j = 1, 2, 3 are physical units such as bd. ft., A.U.M., etc. And, the units of measure for b_4, b_5 are dollars. Hence we conclude that:

π_1, π_2, π_3 are \$ per unit output,

π_4, π_5, are \$ per unit of \$ cost.

We see that the first set of shadow prices are marginal output costs and the second are marginal "investment" costs (i.e., the change in total cost per unit of change in the appropriation cost level).

How shall we interpret these? To begin, whenever a constraint is not binding the corresponding shadow price is *always zero!* This means zero cost for a unit increase in the output constraint. For example, suppose b_1 = A.U.M. and our solution yielded 11 A.U.M. Then we could increase the constraint from 10 to 11 A.U.M. at no cost--an obvious conclusion of little interest to a manager because the model already reports attained outputs in excess of the minimum levels. However, when a constraint is not binding, the shadow price is the marginal cost of a unit incremental change in the constraint value (either a unit increase or a unit decrease)

for the problem *as defined.* Hence there is a *set of prices, one set for each problem.*

The meaning of the second set of "shadow prices" (π_4, π_5) is more obscure. The change in total cost per unit change in appropriation level tells a manager *nothing* about increases in <u>any</u> output per increase in any given appropriation level. It tells him which of the appropriations are binding and gives the *relative* ranking of the needs for funds to enable him to *decrease* his total cost. Note, however, that many projects in a real budget proposal do not have real outputs and would never be selected if the problem were stated as above. In practice then, we often use equalities rather than inequalities for appropriations constraints so that after choosing projects with outputs, the balance of funds is used for non-output projects.

Also, in practice the forest did not specify minimum outputs but instead an output appeared as the objective to be maximized. In this case the problem is the same as before except that we maximize, say the 1st output, i. e.

$a_{11} x_1 + a_{12} x_2 + \ldots + a_{16} x_2$ = maximum, subject to appropriations constraint, and a minimum level of the second output.

Then $\pi_1 = 0$ because the 1st constraint has disappeared and π_2 and π_3 are the changes in the first output per unit changes in the other output. Moreover, π_3, π_4, and π_5 are interpreted as the change in the 1st output per unit change in appropriation levels. However, in F. Y. 1969 since there was a *set* of eleven shadow prices, one *set* for each maximization, the Eldorado Supervisor would have had *fifty-five* prices to digest for each bundle of appropriations.

In the absence of specified output goals, no single unique problem can be said to be the problem, even for a given year, much less from year to year. Hence, the use of "shadow prices", as an analytical aid, is of questionable value.

On the other hand, whenever the coefficient matrix, for outputs at least, defines a relatively static production function, "shadow pricing" may be of some limited value. The limitation arises from the fact that shadow prices are *non-unique*, because they depend on the choices of constraint levels and objective functions, which are changed in order to explore possible solutions. The result is a *family of sets of shadow prices.* An eloquent discussion of pricing is contained in Dantzig (1) chapter 12.

E. Efficient Points & Non-Uniqueness of Output Prices

In the previous discussion of "shadow prices", no mention was made of whether or not output prices were unique or not. We now examine this and a related question.

Gale (4) chapter 9, describes the properties of some models of production. In section 4 he describes a "General Linear Production Model" whose *mathematical structure is identical* to the Eldorado annual model. The model has two principle properties: efficient points and non-uniqueness of output prices. The first is of the most interest.

Property No. 1. Each solution is efficient. This means we cannot obtain more of some output without giving up some of another. Efficient solutions are non-unique. There may be numerous efficient solutions for the same set of input levels. This property gives a manager the assurance that the best solution has been obtained in terms of outputs vs. inputs.

Property No. 2. Each solution corresponds to non-unique prices. In words this means that there is an infinite set of output prices for each solution.

Information is obtainable about output prices namely the price range, for each output (relative to each other) for each solution. (Some computer codes have a "cost ranging" feature

which computes these ranges.) Oregon State University, which wrote the REX Linear Programming System, is extending these "cost ranging" features to REX. We know this but we do not know how a forest or region can use it. Bill Shirley and George Perry felt that some use can be made of this sort of information. MaSS offered to explore this further. Shadow pricing is a useful tool, but its use now is pre-mature, expecially in view of the absence of explicit demands for outputs. We have found that the simplest case of easily interpreted marginal values are hard to use without gaging outputs attained against explicit output demands.

F. The Simplex Algorithm as a Method for Expansion Along an Optimal Path

The annual budget model uses a linear production function. The simplex algorithm has the following property: it traces a path on the multi-dimensional "production" surface for each objective function. The path is optimal in the sense of "steepest ascent" -- each iteration is begun by selecting a new direction which yields the largest incremental contribution to the objective. It proceeds along that path until it reaches a vertex at which point it selects a new direction, etc. The process continues until optimality is reached. Hence, it can be said that the simplex algorithm is a method for tracing an optimal expansion path along a linear production function surface.

G. Notes on the Manpower - Network Flow Computations

Using linear programming for manpower distribution implies an excessive amount of computer time. Our experience with Eldorado F. Y. 1969 and 1970 budget runs indicates that it will seldom if ever be necessary to constrain parts of the manpower net itself, such as shortages and excesses to satisfy a Forest Supervisor. Instead, he considers a distribution satisfactory if (1) total shortages and excesses are roughly equal and (2) excesses are of higher orders of skill than shortages. When the distribution is unsatisfactory, he is reluctant to specify precisely how to constrain it to

achieve a satisfactory solution. Instead, he selects an alternative budget from the array. We concluded that manpower distribution can be computed separately after projects are selected. Decomposing the original problem, in this way, still permits us to include constraints on manpower *used* by skill by season by sub-unit, as part of the L. P. section of the model. When this was done the size of the L. P. matrix was much smaller because the matrix generator part of the ADP design writes equations only for actual constraints needed for each problem.)

The scheme is as follows: solve a L. P. problem for the best project mix with money, output and manpower used as constraints; then use the manpower-needed vector as the set of demands for the manpower distribution problem.

This procedure permitted us to consider a more efficient algorithm for making the manpower distribution. Accordingly, we translated our transportation-type problem into a network flow problem and used the Ford-Fulkerson algorithm. Paul Baerman and Louis Visser of R-5 wrote the computer program for this algorithm which then became an optional "component" of the Annual Budget Model.

V. USING THE ELDORADO ADP SYSTEM FOR OTHER PURPOSES

A. Solving other Problems

The ADP system may be used for solving problems other than budgeting as we used it in the experiment. For example the system can be used for summarizing and reporting (without project selection). It can also be used for merely solving a general linear programming problem. Finally, it can also be used for merely solving a Hitchcock Transportation Problem rapidly via the network flow algorithm. In every case, the ability of the system to report summaries may be advantageous to a user. Some notes on these examples follow.

Consider a general linear programming (L.P.) problem (not a transporation problem). The activities (or columns of the coefficient matrix) are what we called projects. In contrast to most L. P. systems, in which all rows are of the same character, we have partitioned the rows into sections, each section serving a different purpose. This feature permits us to summarize activity (project) information in different ways without the necessity of doing so via linear programming. Hence, although the entire coefficient matrix is key punched, only the portion needed for the problem is used for the L.P. solution, because the matrix generator program writes only the appropriate rows for the REX L.P. system. In other words, the function of "bookkeeping" which produces summaries may be part of the problem statement but it is not part of the L.P. coefficient matrix. Let us illustrate the idea of bookkeeping in the following example of a 6 activity L.P. problem, where X_i, $i = 1, 2, \ldots, 6$ are the activities levels.

$$X_1 \quad X_2 \quad X_3 \quad X_4 \quad X_5 \quad X_6$$

$$c_1 \quad c_2 \quad c_3 \quad c_4 \quad c_5 \quad c_6 \quad = \quad Z \text{ (min)}$$

$$a_{11} \; a_{12} \; a_{13} \; a_{14} \; a_{15} \; a_{16} \geq b_1$$

$$a_{21} \; a_{22} \; a_{23} \; a_{24} \; a_{25} \; a_{26} \geq b_2$$

$$a_{31} \; a_{32} \; a_{33} \; a_{34} \; a_{35} \; a_{36} \leq b_3$$

Suppose we wish to report the sum of activities 1, 2, 3 i.e., we wish to report the sum: $X_1 + X_2 + X_3$. Then we could add the equation:

$$X_1 + X_2 + X_3 - S_1 = 0,$$

where S_1 is the sum we want. Now suppose we wish also to report the sum of activities 2, 5 and 6. Again we could add the equation:

$$X_2 + X_5 + X_6 - S_2 = 0,$$

where S_2 is the desired sum. Finally, suppose we wish also to report the "cost" of activities 3, 4 and 6, where the cost coefficients are c_3, c_4, c_6,. We write

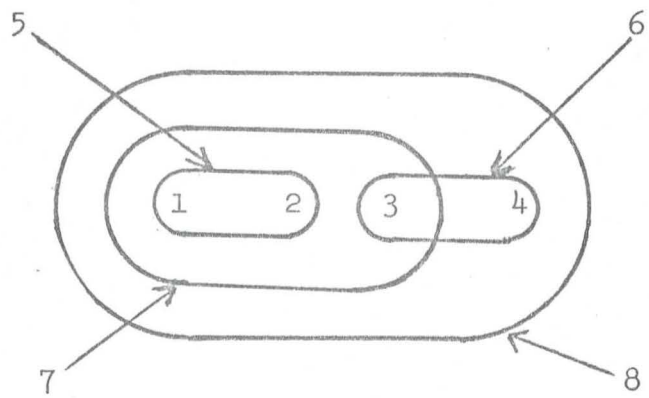
$$c_3 X_3 + c_4 X_4 + c_6 X_6 - S_3 = 0,$$

where S_3 is the desired sum. With these examples in mind, we assert that when using the Eldorado ADP system, it is not necessary to define explicity S_1 S_2 S_3 nor the corresponding equations as we did above. Instead, control cards are available for obtaining these summaries.

Now we consider some remarks on specific sections of the input which may aid one in using the ADP system for other purposes.

a. Manpower. In addition to using the network, we can constrain and/or report hours used by skill, by season, by sub-unit, by combined skill/season, or by combined skill, season, sub-unit, using Part 5.

Note: Manpower sub-units may be defined in various ways by user. For example, suppose we have 4 sub-units and we define sub-unit 5 as the combination of sub-units 1 and 2. Similarly, we may define sub-unit 6 as the combination of sub-units 1, 2, and 3. The schematic below describes these:



b. Form 1300-4 x

(1) Part 4. We constrain and/or report items by cost categories. These may be defined as combinations of fund and program staff. Hence we may constrain: (a) by "fund" individually, or by pair, by triplet, etc., (b) by "program class" (activity code) by pair, by triplet, etc., (c) by any combination of "fund" and "program class" by pair, by triplet, etc. Rules and methods for forming combinations are analagous to those described above under manpower, i. e., via defining new sub-units.

(2) Part 6. Resource output items herein may be constrained and reported Forest-wide only (i. e., unit-wide) not by sub-unit.

c. Upper bounding Implied. The project (activity) level is automatically upper bounded at unity. That is, if X_i is the level of activity i, then $0 \leq X_i \leq 1$ for all i is implied except when some X is frozen or when some other specific upper bound is specified.

d. Frozen Activities. Activity levels may be frozen at any specific level including negative values. An entire priority class of projects may be frozen at unity by simply stating the class or by stating up through priority, hence obtaining solutions containing entire priority classes.

e. Minimize vs. Maximize. The objective function is automatically maximized if the objective control is alpha (an output category) but it is minimized if the control is numeric (a cost category). Also, note that in category "N" we cannot use code 999 because this sums the amounts in Part 4 to get the "all projects run" i. e., a summary of all the activities (columns in the matrix).

f. Project (Activity) Group. Any number of activities may be defined to be members of a group. The group is treated as one single activity in the solution and activity levels are reported by group in a special report.

B. Linking Outputs to Inventories

During the course of the three annual budget trials, we considered several methods for storing and retreiving output data, in particular, the measurements of changes in outputs (often called output coefficients). Such information is treated as standard data because it changes little from year to year. Hence we thought it was worthwhile to spend some time thinking about how this data could be conveniently stored and handled.

These data (e.g., output changes per acre of treatment) are recorded and stored most conveniently in tabular form. The tables can be in book form if they are to be used by the forest staff for completing the project work proposal form 1300-4X. This has the advantages of focusing the planners' attention on outputs during work planning. Its disadvantage is the risk of errors in transcribing information from the tables to the form.

A rather different method involves storing the output data in the computer (on an ADP disc file). In this case, the planner records only the address on the 1300-4X form (PWP), the address being a description of the project in standard form. The standard form is a five-part description as follows:

- main treatment class (a broad description of activity type such as thinning or engineering design)
- work method (e. g., mechanical or chemical)
- land use (current use of the land)
- resource characteristic (land condition such as vegetative type)
- land class (an additional description, e.g., erosion potential, vegetative type or timber site class)

The ADP system can be used with output data recorded by either of the two methods discussed above. If output data is entered by the planner in part 6 of the PWP form 1300-4X, it automatically over-rides output data computed from the address, if any, entered in part 8 of the form. This illustrates

how either of the methods may be used separately and how they may both be used simultaneously. (For a description of these parts, see section IX of this report.)

The first method discussed above was used for F.Y. 1969. The latter method, used for F.Y. 1970 and 1971, may be viewed as a first step toward a more complete ADP system which links outputs to land inventories and in turn links these to a map information system such as the Wildland Resources Information System (WRIS) currently under development at the PSW Station in Berkeley. We did not pursue this idea for long, because it was beyond the scope of our work. However, it appears feasible to extend the standard form of describing project work so as to describe all of the acres on the Eldorado. This would permit linking outputs to inventories and, in turn, using WRIS, it would permit linking outputs to map information.

Describing work in a standard form on the PWP, as we have done, also is a first step toward obtaining standard cost data for estimating the cost of future work. The task descriptions used as keys for locating a standard list of outputs are the same types of descriptions one needs for locating historical costs. In short, the new accounting system could be geared simply to provide historical cost data useful for estimating future costs because the project number is the same in both the new accounting system and the PPB system we used.

VI. NOTES ON SERVICE-WIDE MODELS

A. Model No. 1

Our initial concept stems from an important assumption: that Regional proposals must be feasible for each Forest. The only way to achieve this, Servicewide, is to make sure that every forest and regional program is feasible initially. Therefore we do not define regionwide activities with regional average outputs and costs; instead, building blocks for a Regional Model are Forest-wide, feasible programs. Any number of such programs may be submitted by a forest. As pointed out by Associate Deputy Chief Payne, this approach features programs that are developed at the Forest level, aggregated at the Regional level and again aggregated at the Washington Office level. Hence, the flow of proposal information is "from the bottom up."

There are two methods for forest programs. (1) A forest program is accepted or rejected in its entirety, with at least one from each Forest. (2) An alternate version allows interpolation between proposals. Since these Forest-wide programs usually comprise many small projects most of which can be partially funded, then the latter version, (i.e., linear programming) may be used to help in the calculations. Also, the second approach provides more flexibility. A limitation of the linear programming approach might occur if a forest proposal contained all "go, no-go" projects for a given fund and a second proposal is the same as the first except for dropping a project. Then interpolation between the two is meaningless, otherwise it makes very good sense. In either version, data input and reports are identical, the only difference being the selection procedure.

In a servicewide model, regional proposals become the building blocks and act in the same way that Forest-wide proposals do in a regional model. Alternative regional

proposals are forwarded to the Washington Office, which in turn aggregates them the same way the region aggregated forest proposals. *The distinct advantage of this approach is that every proposal is feasible at every stage; hence the combination of feasible proposals is also feasible.*

In the list of assumptions we stated that four levels of organization will remain unchanged. This implied a large degree of local autonomy, and, therefore some sub-optimization in the mathematical sense. However, this should not preclude some knowledge of the cost of doing so.

In our discussion of this model and the next one, we assumed that the planning cycle begins with goal setting by the Washington Office for each region, then goal setting by each region for its forests.

B. A Functional Regional Model

Suppose all projects in the "bank" are submitted directly to the Region and all projects funded by, say, 070 money are sent to the Regional Staff Officer concerned with 070 money. He can use these as activities in a model for developing alternative region-wide "070 programs," subject to constraints which provide a minimal share of the 070 funds for each forest. The measure defining the best proposal can be the "dominant" output (the single ouput which is the principal reason for the project). In this fashion, alternate programs for each function can be developed and these programs become, in turn, the activities ("building blocks") of an "executive" regional model. Hence, a regional model would comprise a set of 070 programs, a set of 031 programs, etc.

This model is difficult to use for allocating funds as follows: (1) how to obtain a feasible program for an individual forest, not for just 070 money but for the entire forest budget (particularly in terms of manpower constraints); (2) primary outputs are likely to be of paramount importance--joint outputs are likely to be given minor consideration. Also, the selections done at the regional level give a minor voice to the Forest Supervisor. His role would be to develop the best project proposals, but he would have little voice in program "balance," hence he could not plan for a desirable bundle of outputs at least cost.

Since transfer of funds between functions is restricted, projects compete only within a function. This lack of "across-function-competition" implies sub-optimization in the mathematical sense of a different sort from that of the previous model.

An advantage of this functional model is that it more closely follows traditional budget practices. If it is more desirable to maintain decision-making on a functional basis at the Regional Office, then as we have outlined here, appropriate functional models can be developed.

C. Using the Same Model for Proposals and Allocations

What problems may arise because of the time gap between

the proposal stage and the allocation stage?

1. Inverse Process. Management is generally free of stringent functional and appropriation restrictions when making proposals for the future; whereas, it is not as free during the allocation process. Hence, each process may be viewed as the inverse of the other. When is a model reversible, useful for proposals and for allocating fixed amounts of appropriations? Our experience using the Eldorado Budget Model showed it to be reversible. But the gap in time between proposal and allocation was negligible. This will not be true in general and a gap of up to two years may be required. Conditions are likely to change during such a gap posing the following problem: whenever allocations do not match proposed programs, forest programs must be adjusted and expectations for corresponding outputs may no longer hold. Hence actual programs will always differ from earlier proposals both in terms of outputs and in the blend of appropriations and functions. (This is true of both models discussed herein.)

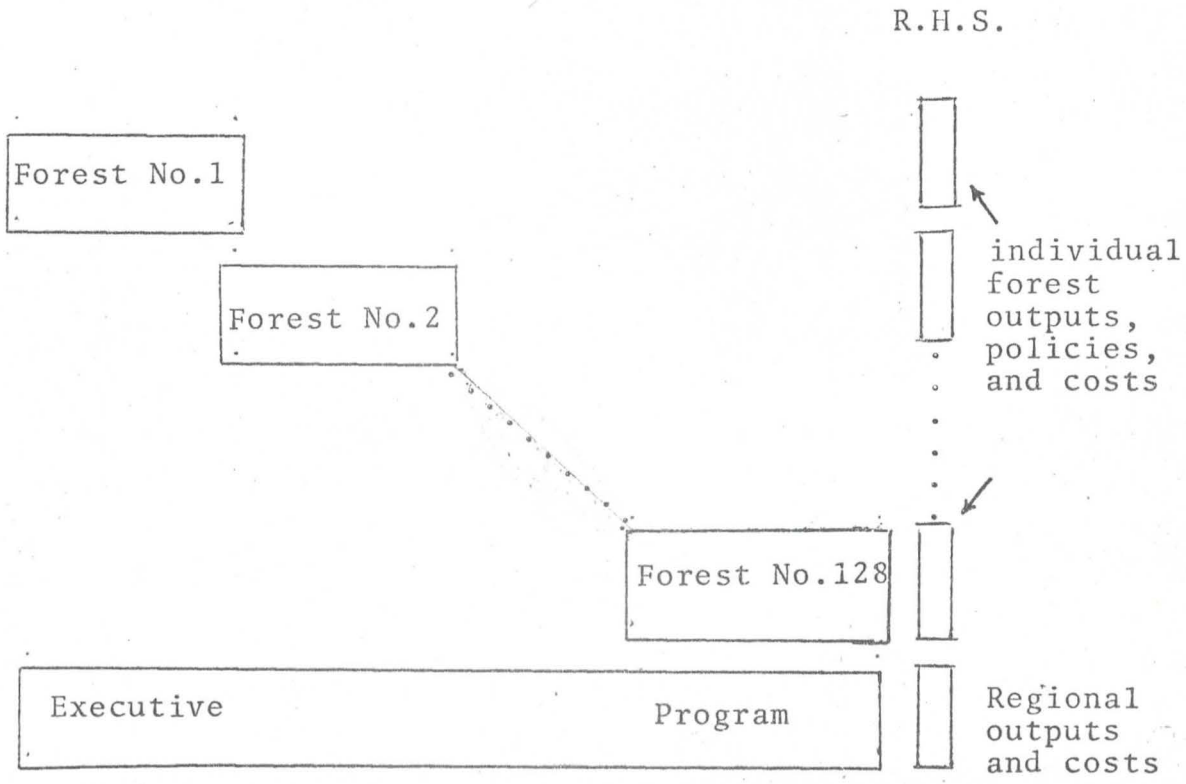
2. Using Proposals for Allocating. Can the original (Forest-wide and Region-wide) proposals be used for allocating or must new proposals be used? The answer depends on how great is the difference between actual allocations and the range of alternatives contained within the proposal bank. It also depends on whether the original proposals are still feasible "on-the-ground." Hence, we see an advantage in having feasible programs to begin with, i.e., when a servicewide proposal is an aggregation of feasible regional proposals, each of which in turn is an aggregation of feasible Forest-wide proposals, etc. If the original proposals are sufficient for allocating, then rapid feedback of new output information is not needed. In this case, a natural medium for such updating may be the existing "Attainment Reporting System" or the new Accounting System because both lag behind the time when final allocations occurs.

If the original (Forest-wide and Region-wide) proposals are not adequate, then W.O. would need new updated proposals to allocate. For example, suppose original proposals were based on stable budget expectations and each region developed

proposals which fell within $\pm$ 5% of last year's funds. Suppose further the W. O. actually received 10% below expectations. Then it would need new regional proposals in order to know what outputs to expect from an allocation alternative. Considering the relative stability of past performance, setting a range of values which straddle expected appropriations is certainly possible. Additional flexibility for allocating may come from flexible overhead distribution.

D. The Decomposition Principle

Consider linking together a series of forest input-output matrices of the type already discussed in section IV to form a single structure. A schematic of this might appear as follows; where R. H. S. means right hand side of the inequality (equality) signs.



Each National Forest has a separate matrix that may be used to study local problems. The matrices are combined to form a matrix for a Region. The combined matrix has the "block-angular" structure described by Dantzig and Wolfe (3), suggesting the use of the Decomposition Principle.

The "staircase" structure corresponds with the formal organizational structure and suggests the use of the Decomposition Principle (see Dantzig (3)). Baumol and Fabian(1) discuss a problem of coordinating a decentralized, multi-division company similar to the National Forest System. We considered these ideas very early in our work. Using the Decomposition Principle poses two very practical problems: first, selecting an objective function, appropriate to each forest; and, second, the large number of iterations, each of which requires transmitting information (π - values) between organizational levels. Transmittal is a slow process. A poor set of alternative proposals in the master program gives rise to erratic behavior of π values on common rows which, in turn, lead to non-sensical optimum solutions to the sub-problems. This problem may be overcome partially by giving the master program a wider choice during the first few iterations and providing good initial solutions.

But the number of iterations (and transmittal of prices to each lower level) is very likely to exceed two or three by a wide margin--a feature which we thought the organization would not tolerate. Hence we considered this approach as infeasible.

VII. SAMPLE PRINTOUTS OF THE FINAL REPORTS

Exhibit 13 is a sample taken from several proposed F.Y. 1970 or F.Y. 1971 programs for the Eldorado. The sample represents the final "production" version. The F.Y. 1970 proposal comprised the best mix of 607 projects from a total project "bank" of 719 projects, subject to satisfying priority requirements and known budget levels.

Exhibit 13 has twelve pages. The page numbers correspond to the page numbers of Appendix D of the report entitled "PPBS - Automatic Data Processing Description and Specifications for One-Year Forest Model Automation" from which these pages were excerpted.

Not all projects result in measurable outputs; hence, to make sure those desired were included in the proposal, they were (1) either specified as high priority, (2) or controlled via a constraint such as "spend at least $193,000 KV money." The title "Maximum Recreation Environment" means that this proposal gave the maximum possible "relative effect" for recreation environment. (Other proposals were considered which used other measures of effectiveness such as the combined timber growth and timber regeneration growth.)

Pages D 4.0 and 4.1 show Forest-wide summaries of actual outputs and relative effects. Relative effect may be understood by comparing the 8027.6 acres planned for fire accessibility showing the actual output summary, with the value of 6713.8 acres for fire accessibility shown on the relative output summary. If all acres treated had enhanced the hour control standards by one hour, both values would have been 8027.6. But some acres treated were enhanced only partially and the relative value, 6713.8 reflects this.

Pages D5, D 5.01. Forest-wide costs by appropriation and function.

Page D6. This is how the budget looks broken down by subunit, by appropriation. Fund 02 means P&M, 15 means FR&T, etc. "Proposed" means the entire project "bank." Actual refers to selections for this run. We hope the new accounting system policy of not functionalizing money below the Forest level will

eliminate this report in the future.

Page D 7.01. This shows total cost and work units for each activity. It is printed by unit and ordered by activity. Throughout this page you see the forest program in traditional (input) units of measure: miles, acres, manhours, etc. It contains columns for activity, activity description, proposed and planned units of work, and proposed and planned costs. Cost totals are accumulated and printed for each primary activity group, the unit, and the region. Similar reports exist for other activity groups such as engineering, etc. This report matches the Eldorado PPB program with the new accounting system. Our plan was to use the final PPB program (on tape) as input for accounting. "Proposed" units and dollars refers to entire project bank.

Pages D 8, D 9, D 9.01. Here are reports for each district, the S.O. and the forest as a whole showing manhours by skill by season:

(1) Permanent people required
(2) Temporary people required
(3) Total people required both permanent and temporary
(4) Excess (generally the higher skilled excess hours may be used to satisfy shortages).

For this proposal, the Supervisor specified that the manpower network allowed "flow" from S.O. to districts but otherwise no inter-unit "borrowing."

Page D 10. This is a list of the projects selected as a work program. It shows: sub-unit, proposal number, priority levels, description, activity, planned work units, and proposed and planned cost for each project selected. It is ordered by primary activity, project number, except that grouped projects are listed last.

Page D 11. This is a worksheet used by the Deputy Forest Supervisor for manually recording progress for each project at anytime during the year. This report will probably be similar to that which the new accounting system will provide.

Page D 13. An experimental report. Projects are grouped by sub-unit.

O U T P U T S U M M A R Y - A C T U A L

X1300-4 (CPO) PPBS RESOURCE OUTPUT SUMMARY 10/29/69

UNIT 03 ELDORADO 0015999

SECTION 1 DISTRIBUTED OUTPUTS

SEQ	CATEGORY	PROPOSED	PLANNED	CONSTRAINT
002	ATG TIMBER GROWTH	2254.6 M.B.F.	1922.5 M.B.F.	
004	ATC TIMBER CUT	189309.0 M.B.F.	150545.2 M.B.F.	
006	ATR TIMBER REGENERATION GROWTH . .	1262.6 M.B.F.	935.5 M.B.F.	
008	ARM LIVESTOCK GRAZING	18.0 A.U.M.	10.0 A.U.M.	
010	ANM WILDLIFE GRAZING	381.7 A.U.M.	334.6 A.U.M.	
012	AHR WATER RUNOFF	.3 M.ACF.FT	.2 M.ACF.FT	
016	APR PRODUCTIVITY RESTORED	287.0 ACRES	294.0 ACRES	
017	ARV RECREATION VISITATION	3145448.0 VIS DAYS	3069198.0 VIS DAYS	
018	AFD FISHERMAN DAYS.	12081.2 VIS DAYS	6403.8 VIS DAYS	
020	AHD HUNTER DAYS	15714.8 VIS DAYS	9014.3 VIS DAYS	
022	ACP CAMPING AND PICNICKING	105767.0 VIS DAYS	50767.0 VIS DAYS	
024	AST SCENIC TRAVEL	27119.8 VIS DAYS	13370.8 VIS DAYS	
026	AFA FIRE ACCESSIBILITY	8150.0 ACRES	8027.6 ACRES	

D 4.0

O U T P U T S U M M A R Y - R E L A T I V E

X1300-4 (CPO) PPBS RESOURCE OUTPUT SUMMARY 10/29/69

UNIT 03 ELDORADO 00159999

SECTION 1 DISTRIBUTED OUTPUTS

SEQ		CATEGORY	PROPOSED	PLANNED	CONSTRAINT
028	RTG	RELATIVE TIMBER GROWTH	13882.5	12024.5	
030	RTC	RELATIVE TIMBER CUT	3134.4	2312.5	
032	RTR	RELATIVE TIMBER REGENERATION	1345.5	1233.5	
034	RRM	RELATIVE LIVESTOCK GRAZING	115.2	75.0	
036	RWN	RELATIVE WILDLIFE GRAZING	1376.3	1164.6	
038	RHR	RELATIVE WATER RUNOFF	3978.2	3368.4	
040	RSS	RELATIVE SOIL STABILITY	2513.0	2756.7	
042	RWR	RELATIVE WATER QUALITY	1600.8	1845.4	
044	RRE	RELATIVE RECREATION ENVIRONMENT . . .	6426.5	6426.4	
046	RRV	RELATIVE RECREATION VISITATIONS . . .	5586.1	5475.1	
048	RFH	RELATIVE FIRE HAZARD REDUCTION	504.5	196.4	
050	RFA	RELATIVE FIRE ACCESSIBILITY.	6775.0	6713.8	

APPROPRIATION TOTALS

X1300-5 (CPO) PPBS COST CONTROL SUMMARY 10/29/69

UNIT 03 ELDORADO 00159999

CONTROL LINE	DESCRIPTION	PROPOSED (1)	PROPOSED (2)	PLANNED (1)	PLANNED (2)
0002	TOTAL 002 P AND M	2708594		2179464	
0004	TOTAL 004 INSECT AND DISEASE CTL	11839		10008	
0006	TOTAL 006 WATER RELATED DEV RA	491193		110407	
0015	TOTAL 015 FOREST ROADS AND TRAIL	2765832		2044160	
0024	TOTAL 024 KV	241080		192867	
0027	TOTAL 027 WCF	56466		26494	
0035	TOTAL 035 BRUSH DISPOSAL	31975		24927	
8001	TOTAL COOP + RIEMB. ACCOUNTS - 025	63879		54519	
8002	TOTAL COOP + RIEMB. P + M	61996		61996	
8003	RIEMB. 027 WCF	120		120	

FUNCTION	DOLLAR TOTALS	PROPOSED	PLANNED
2031	PM-031 TIMBER RESOURCE MNGMT	593060	436727
2032	PM-032 TIMBER MNGMT PLANS	5809	4996
2033	PM-033 REFORESTATION	18544	16039
2034	PM-034 TIMBER STAND IMPROVEMENT	29920	16445
2035	PM-035 NURSERIES	3425	821
2036	PM-036 FOREST TREE IMPROVEMENT	101730	82995
2043	I+DC-043 OTHER TREE DISEASE CTL	760	321
2044	I+DC-044 INSECT CONTROL	4924	4175
2045	I+DC-045 WHITE PINE BRC TECHNCL	3906	3630
2046	I+DC-046 I+DC TECHNICAL SERVICES	2249	1883
2051	PM-051 RANGE RESOURCE MNGMT	28328	21812
2052	PM-052 RANGE REVEGETATION	5623	3484
2053	PM-053 RANGE RESOURCE IMPROVMNTS	20344	12689
2061	PM-091 SPECIAL LAND USES	19953	13708
2062	PM-062 LAND MNGMT - MINERALS	3489	2510
2067	PM-067 LAND ADJUSTMENTS	26405	20040
2068	PM-068 LAND LINE, CORNER LOCATN.	20021	10437
2069	PM-069 LAND STATUS	1624	1039
2070	PM-070 RECREATION USE	1314847	1171393
2080	PM-080 WILDLIFE HABITAT MNGMT	52808	18693
2091	PM-091 SOIL, WATERSHED SURVEYS	75914	53634
2101	PM-101 FOREST FIRE PREVENTION	299554	233521
2110	PM-110 MAINTENANCE OF IMPROVMNTS	45142	30542
2111	PM-111 CONSTRCTN OF IMPROVEMENTS	13272	9214
2270	-WRDRA-070 RECREATION IMPROVEMENTS	460689	99994
2292	WRDRA-092 SOIL AND WATER MNGMT	30504	10413
2433	KV-033 REFORESTATION	99593	90582
2434	KV-034 TIMBER STAND IMPROVEMENT	141487	102284

2711	WCF - 011 EQUIPMENT MANAGEMENT	14530	7265
2735	WCF - 035 NURSERY STOCK PRODUCTION	3478	
2740	WCF - 040 NURSERY	38458	19229
3501	RR DISPOSAL-101 FF PREVENTION	31506	24531
3531	RR DISP-031 NURSERIES	469	369
5121	FR+T-121 ROAD MAINTENANCE	245472	202493
5131	FR+T-131 TIMBER ACCESS ROAD CON.	83203	61107

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X1300-6 (CPO)

APPROPRIATION TOTALS BY DISTRICT

PPBS APPROPRIATION SUMMARY 11/03/69 PPB104

UNIT 03 ELDORADO

0016RRE

SUB-UNIT	FUND	PROPOSED	/ PLANNED	REIMBURSEMENTS		COLLECTIONS	
55 PACIFIC	002 P + M	171006	161077	19833	19833		
	004 1 + DC	791	699				
	006 WRDRA	32874	32374				
	015 FR + T	15052	11415				
	024 KV	9798	8432				
	025 COOP					12706	12705
	035 BR DISP	2238	2133				
	TOTALS						
	NON-R OR C						
	REIMBURSEMENTS	231759	216130				
	COLLECTIONS	19833	19833				
		12706	12706				
	ALL APPROPRIATIONS	264298	248669				

ACTIVITY SUMMARY - 2 RANGE, RECREATION, TIMBER
X1300-7 (CPO) PPBS ACTIVITY SUMMARY 10/29/69

UNIT 03 ELDORADO 00159999

ACTIVITY	DESCRIPTION	PROPOSED	/	PLANNED	UNITS	PROPOSED	/	PLANNED	PERCENT
22230	RANGE PLANT CONTROL	60.0		60.0	AC.	1230		1230	100.00
22311	MNT OF STRUCTURAL RANGE IMPROVEMENTS FENCES	57.1		50.1	MI.	4206		3065	72.87
22312	MNTN OF STRUCTURAL RANGE WATER DEVELOPMENTS	32.0		16.0	EA.	998		200	20.04
22313	MNT OF STRUCTURAL RANGE IMPROVEMENTS-OTHER	6.0		1.0	EA.	479		110	22.96
22321	CONSTRUCTION OF RANGE WATER DEVELOPMENTS-SPRINGS	1.0		1.0	EA.	519		519	100.00
22331	CONSTRCT OF OTHER RANGE IMPROVEMENTS-FENCES	2.8		1.5	MI.	2293		360	15.70
22335	CONSTRUCTION OF RANGE IMPROVEMENTS-OTHER	5.0		1.0		899			20.00
22000	TOTAL					43660		37985	87.00
23010	RECREATION MGMT-PROGRAM MANAGEMENT	6997.0		6901.0	MANHOURS	248827		241449	97.03
23110	OPR+MNTN CLNUP-UNDVLP ARS, XCLED NRA+WLDRS	1583500.0		1583500.0	V.D.	9154		9154	100.00
23120	OPR+MNTN CLNUP-DVLP SITES, XCLD NRA+WLDRNS	1068900.0		1068900.0	V.D.	89584		89584	100.00
23121	COLLECTION OF RECREATION USER FEES	.0		.0		18028		18028	100.00
23130	MAINT OF DEV. SITES - EXCDNG NRA AND WILDRNESS	7413.0		7073.0	PAOT	27339		26737	97.50
23140	OPR+MNTN CLNUP+MNTN IN WILDERNESS AREAS	65000.0		65000.0	V.D.	6625		5861	88.47
23170	VISITOR INFORMA SEP-CLNUP, MNTN,+MANNING	23228.0		23228.0	V.D. CNT	24955		24955	100.00
		189661.0		189661.0					
23180	OPR+MNTN ADMN OF RECREATION COMMERC SPECIAL USES	1056.0		1056.0	HRS.	7906		7906	100.00
		12.0		12.0	EA.				
23210	SITE PLANNING	6770.0		4890.0	PAOT	29156		20135	69.06
23220	DVLPMT-OLY IMPRVMT RECREA FCLT XST, XCLD NRA SIT	905.0		905.0	PAOT	11445		11015	96.24
23222	DVLPMT CNSTRCT NEW FCLT, INCLD NW STRCT XCLD NRA	2507.0		2792.0	PAOT	429066		93031	21.68
23250	DVLPMT-CNSTRCT-MINOR VIS IMPRV (LS $50,000+OVER)	290.0		250.0	PAOT	5239		3560	67.95
		3.0		1.0					
23300	DVLPMT-WATER POLLUTION ABATEMENT	1015.0		1015.0	AC.	709867		709867	100.00
		30.0		30.0	EA.				
23000	TOTAL					1617191		1261282	77.99

MANHOUR SUMMARIES - FORESTWIDE
X1300-9 (CPO) 1 of 2
UNIT 03 ELDORADO NF PPB MANPOWER SUMMARY DATE 05/04/70
SUB-UNIT 0 ELDORADO 9999 PRIORITY 1 THROUGH 25 ELDORADO BUDGET PLANNING
SECTION 1 MANPOWER REQUIREMENTS

	SKILL CATEGORY	PERMANENT			TEMPORARY			PERMENENT + TEMPORARY			
		FIELD	OTHER	EITHER	FIELD	OTHER	EITHER	FIELD	OTHER	EITHER	CONTRIBUTED
1	MANAGEMENT SUPERVISION	10016	5008	12521	0	0	0	10016	5008	12521	40
3	PROFESSIONAL FORESTRY	13327	9986	14979	11098	0	0	24425	9986	14979	0
5	TIMBER TECHNICIAN-SPECIALIZED	10012	6230	4981	0	0	0	10112	6230	4981	0
7	GENERAL FORESTRY TECH. LABOR	11070	6252	13220	7127	0	0	18197	6252	13220	224
9	LABORERS	4968	1317	922	4594	0	30	9562	1317	952	960
11	FIRE-SPECIALIZED	10219	4291	2428	0	0	0	10219	4291	2428	112
13	FIRE-TECHNICAL	4064	520	480	29816	0	0	33889	520	480	1552
15	RANGE-SPECIALIZED	444	132	0	0	0	0	444	132	0	0
19	WILDLIFE-SPECIALIZED	1016	0	832	130	112	70	1146	112	902	0
21	WILDLIFE-TECHNICAL	0	0	0	0	16	0	0	16	0	0
23	SOIL AND WATER-SPECIALIZED	2036	1462	2058	0	0	0	2036	1462	2058	0
25	SOIL AND WATER-TECHNICAL	0	0	0	80	32	1272	80	32	1272	0
27	RECREATION-SPECIALIZED	5754	2207	2862	0	0	0	5754	2207	2862	160
29	RECREATION-TECHNICAL	4064	366	784	12056	0	0	16120	366	784	484
31	LANDSCAPE ARCHITECT	1424	0	1856	0	0	0	1424	0	1856	0
33	GENETICIST	1616	1148	0	0	0	0	1616	1148	0	0
35	SCALERS	10259	1550	24	0	0	0	10259	1550	24	0
37	ENGINEERING-SUPERVISION	2151	160	5033	0	0	3283	2151	160	8316	0
39	ENGINEERING-DESIGN-SPECIALIZED	40	1712	6508	0	0	0	40	1712	6508	0
40	ENGINEERING-DESIGN-TECHNICAL	2070	1816	300	0	7689	0	2070	9505	300	0
41	ENGINEERING-SURVEY-SPECIALIZED	3316	0	3066	0	0	0	3316	0	3066	0
42	ENGINEERING-SURVEY-TECHNICAL	0	440	10221	53768	0	3009	53768	440	13230	0

43	ENGINEERING-CONTRACT ADMIN.	14224	8604	2592	3522	256	0	17746	8860	2592	0
45	CONSTRUCTION AND MAINTENANCE	11174	5854	5232	0	0	0	11174	5854	5232	804
47	RADIO TECHNICIANS	0	0	1800	0	0	1432	0	0	3232	0
49	EQUIPMENT OPERATORS	5258	2160	536	0	0	0	5258	2160	536	0
53	SUPERVISOR AND STAFF	0	0	0	4840	3636	7868	4840	3636	7868	0
55	ACCOUNTING AND SUPPORT	45628	35209	0	1294	0	0	46922	35209	0	0
57	DISTRICT A.A.	1450	1002	4906	0	0	0	1450	1002	4906	32
	TOTALS	175700	97426	98141	128325	11741	16964	304025	109167	115105	4368

X1300-8 (CP) PPB MANPOWER SUMMARY Date 04/30/70

UNIT 03 ELDORADO NF 9999 PRIORITY 1 THROUGH 25 ELDORADO BUDGET PLANNING

SUB-UNIT 55 PACIFIC SECTION 1 MANPOWER REQUIREMENTS

	PERMANENT			TEMPORARY			PERMANENT + TEMPORARY			
SKILL CATEGORY	FIELD	OTHER	EITHER	FIELD	OTHER	EITHER	FIELD	OTHER	EITHER	CONTRIBUTED
1 MANAGEMENT SUPERVISION	3322	1932	108	0	0	0	3322	1932	108	0
3 PROFESSIONAL FORESTRY	2694	2166	152	2668	0	0	5362	2166	152	0
5 TIMBER TECHNICIAN-SPECIALIZED	1082	1434	80	0	0	0	1082	1434	80	0
7 GENERAL FORESTRY TECH. LABOR	0	0	0	4498	126	16	4498	126	16	0
9 LABORERS	0	0	0	176	100	0	176	100	0	320
11 FIRE-SPECIALIZED	1944	912	0	0	0	0	1944	912	0	0
13 FIRE-TECHNICAL	0	272	0	9448	0	0	9448	272	0	0
15 RANGE-SPECIALIZED	0	0	0	296	132	0	296	132	0	0
19 WILDLIFE-SPECIALIZED	0	0	0	80	80	0	80	80	0	0
23 SOIL AND WATER-SPECIALIZED	0	0	0	0	32	0	0	32	0	0
27 RECREATION-SPECIALIZED	1016	544	48	790	0	0	1806	544	48	0
29 RECREATION-TECHNICAL	0	166	0	4138	0	0	4138	166	0	0
35 SCALERS	1276	332	0	0	0	0	1276	332	0	0
45 CONSTRUCTION AND MAINTENANCE	1000	728	0	528	0	0	1528	728	0	668
49 EQUIPMENT OPERATORS	16	0	0	0	0	0	16	0	0	0
57 DISTRICT A. A.	858	728	104	0	238	0	858	966	104	0
	13208	9214	492	22622	708	16	35830	9922	508	988

D 9.01

X1300-10 (CPO)

PPBS UNIT PROJECT REPORT

UNIT 03 ELDORADO

PROPOSAL

S-U	PROP. NO.	PRIORITY	LEVEL	DESCRIPTION	ACTIVITY	PLANNED WORK	PROPOSED COST	PLANNED COST
				TIMBER MANAGEMENT	24000			
01	15	25	100*	LONG TREE TIMBER SALE ADMIN	24120	24000 MBF	5000	5000
				ENGINEERING	77000			
02	215	30	100*	LOW LAKE EXTENSION COUNT STAKE	77340	1.7 MILES	1737	1737
02	314	30	100*	BIG HILL PICNIC CONST. STAKE	77640	.5 MILES	195	195
						UNIT TOTAL	524,878	421,385

X1300-7A(CPO) SUB-UNIT PROJECT PROGRESS WORKSHEET 11/10/69

UNIT 03 ELDORADO 00159999

51 AMADOR

PROJ NO.	PROG CLASS	SELECTED PROJECT NAME/ ACTIVITY DESCRIPTIONS	PLANNED UNITS PRIMARY		SECONDARY	ACCOMPLISHED UNIT PRIMARY	SECONDARY	PLANNED DOLLARS
0021		AMADOR FIRE PROTECT PLAN 5100-8	100.0	PERCENT				
002	51000	FIRE CONTROL PRGM MGMT	.0	MANHRS	.0			8535
002	51310	PRESUP-ATTACK FORCE-MANNING	24.3	MAN-MO	.0			1060
002	51320	PRESUP-PREVENTION-MANNING	3.8	MAN-MO	.0			1308
002	51330	PRESUP-DETECTION-MANNING	3.7	MAN-MO	.0			2436
035	51320	PRESUP-PREVENTION-MANNING	.0	MAN-MO	.0			3301
R002	00091	PRESUP-PREVENTION-MANNING	.0	MAN-MO	.0			18689
0031		MUD SALE PREPARATION	100.0	PERCENT				
002	24111	TIMBER SALE-COM PREP-RECON	13300.0	MBM	.0			1499
0061		BEAR SALE PREPARATION	100.0	PERCENT				
002	24114	TIMBER SALE-COM PREP-ALL OTHER	5700.0	MBM	.0			2885
0071		LUMBER YARD SALE PREPARATION	100.0	PERCENT				
002	24114	TIMBER SALE-COM PREP-ALL OTHER	13300.0	MBM	.0			1990
0081		LONG VALLEY SALE PREP LAND LINES	100.0	PERCENT				
002	24114	TIMBER SALE-COM PREP-ALL OTHER	.0	MBM	.0			319
0091		PENSTOCK SALE PREPARATION	100.0	PERCENT				
002	24114	TIMBER SALE-COM PREP-ALL OTHER	14300.0	MBM	.0			4598
0101		TRAGEDY SPRING XMAS TREE SALE	100.0	PERCENT				
002	24131	NON-CONVERTIBLE SALE-XMAS TREES	2500.0	NO.TREE	4500.0			654
0121		FIVE CORNERS RELEASE	100.0	PERCENT				
024	24221	TIMBER STAND IMPMT-RELEASE+WEED	40.0	AC	.0			989

(EXPLANATORY NOTES: Under the column headed PROJ. NO., the four digit numbers are project numbers, with the first two numbers implied (e.g. 51). The three digit numbers are fund numbers. An "R" before a fund number indicates a reimbursable fund. In the PROJECT NAME/ACTIVITY DESCRIPTION column, the first entry in each group is the selected project name, while the others are individual activity descriptions. In the column headed PLANNED UNITS: PRIMARY, 100.0% indicates that all of the project is to be done.)

EXPERIMENTAL REPORT - PROJECT LIST

TITLE DETAIL LIST OF PROJECTS BY SUB UNIT, PRIORITY 10/29/69

0016RRE OBJ = PPBRRE

VECTOR	DESCRIPTION	PRIORITY	AMOUNT LEVEL	SC	MEASURE COSTS
***	57, 58, 62 TIMBER MANAGEMENT JACK MOORE	***			
N700210	REMOVAL AND REPLANT 1/2 KNOBCONE ORC	24	1.00		2404
N700610	ORCHARD MAINTENANCE AND HYBRID PROJE	24	1.00		7381
N700110	RESERVOIR REMOVAL	62	1.00		1535
N700410	FIRE HYDRANTS	62	1.00		850
N700310	MAINTENANCE OF LANDSCAPING AT WORK C	71	1.00		734
N700510	RAISING TREES FOR REC. USE INC. TRNG	71	0		3478
N800110	REGIONAL TREE IMPROVEMENT PROJECT	24	1.00		46349
N800210	SCION COLLECTION	24	1.00		5517
0200110	TIMBER MANAGEMENT SUPERVISORS OFFICE	13	1.00		63321
0290210	GA TM SO	13	0		7295
***	63 GRAZING AND WILKDLIFE STAN ZEGER	***			
0300210	IMPACT SURVEY SPECIALIST	13	1.00		14310
0300310	SOIL SCIENTIST	13	1.00		14589
0300410	WILDLIFE BIOLOGIST	13	1.00		12200
0390110	ZEGER 1300-3	13	1.00		11524
0390210	GA ZEGER 1300-3	13	0		6472
***	64 FIRE AND LANDS KEN CLARK	***			
0400610	COMMUNICATIONS NET-REPAIR AND MAINT	13	1.00		18233
0490110	ANNUAL WORK PLAN CLARK	13	1.00		41983
0490210	GA ANNUAL WORK PLAN CLARK	13	0		4022
0400710	FIRE CONTROL SUPPLIES, PER DIEM, AND	14	1.00		4500
0400810	FIRE PROTECTION ORGANIZATION-STATE C	14	1.00		1000
			16.00	*TOTALS*	

REFERENCES

1. BAUMOL, WILLIAM J. and TIBOR FABIAN, "Decomposition, Pricing for Decentralization and External Economics," Management Science 11, No. 1, 1964.

2. DANTZIG, G., Linear Programming and Extensions, 1st Edition, Princeton University Press, Princeton, New Jersey, 1963.

3. DANTZIG, GEORGE B. and PHILLIP WOLFE, "Decomposition Principle for Linear Programs," Operations Research, Vol. 8, No. 1, 1960.

4. GALE, D., The Theory of Linear Economic Models, McGraw Hill, New Yor, 1960.

5. WHALEY, R. S., Multiple Use Decision-Making: where do we go from here?, a report to the Rocky Mountain Forest and Range Experiment Station, Forest Service, USDA, Contract 12-11-204-3: Natural Resource Valuation - The Conceptual and Operational Basis for Economic Analysis in a Multiple-Use Context, 1968, submitted by the Economic Research Institute and Department of Forest Science, Utah State University.